



Investigation of solid particle number measurement: existence and nature of sub 23 nm particles under PMP methodology

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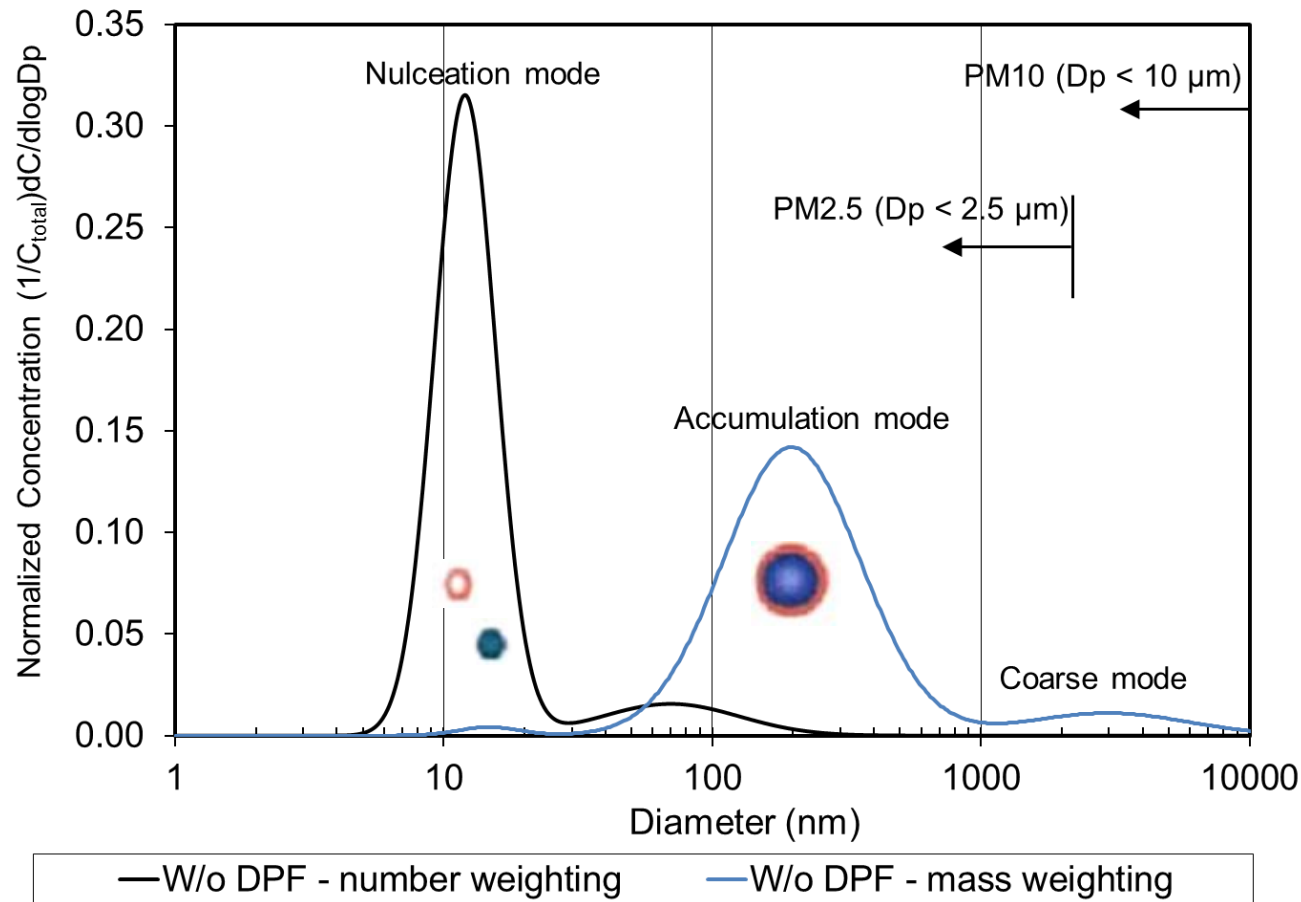
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Typical diesel particle size distribution

Currently, diesel PM is regulated on a mass basis



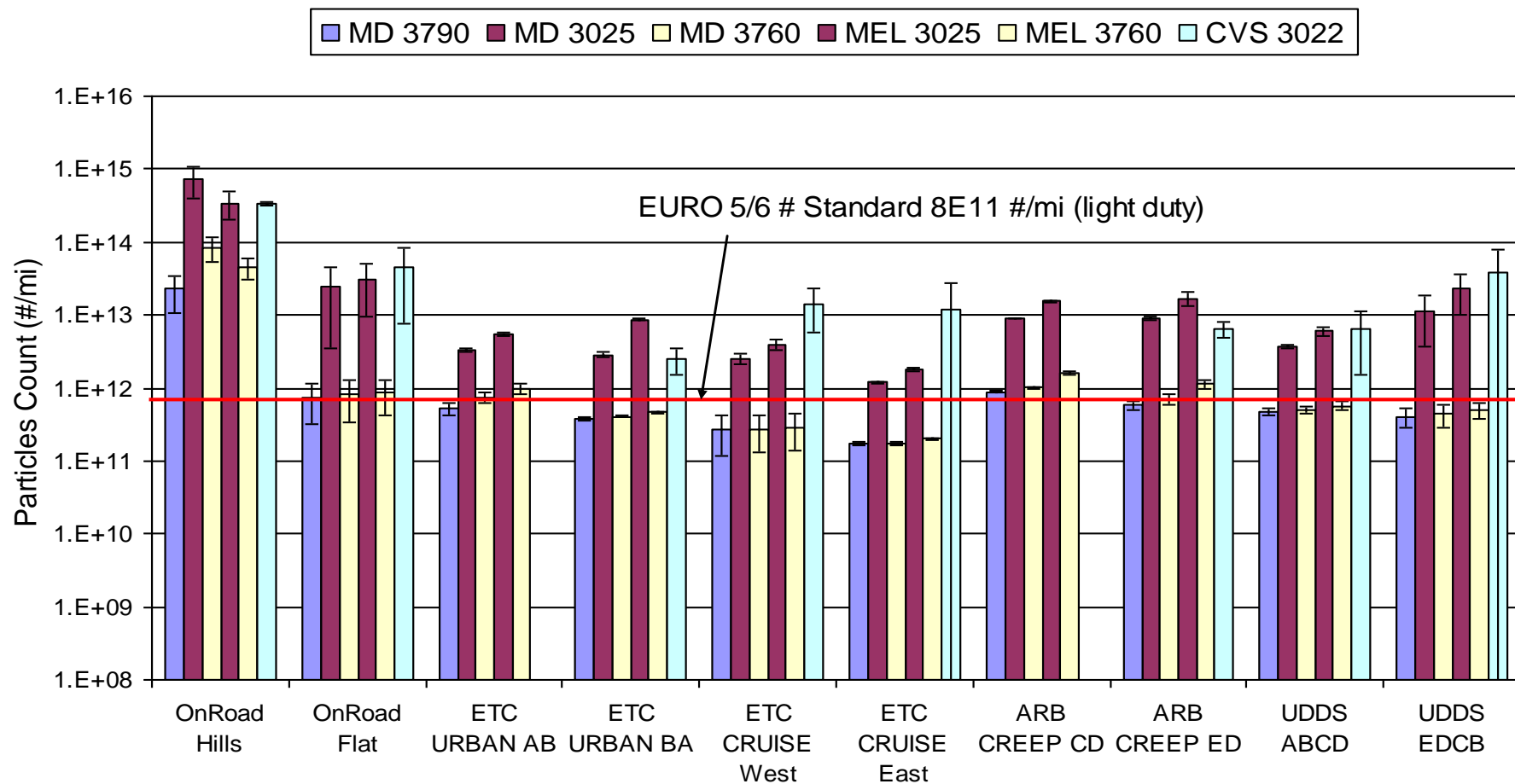


Background

- Current gravimetric method
 - Difficulty quantifying particle mass emissions accurately
- Particle number method
 - The European Particle measurement program (PMP)
 - The PMP measures solid particles bigger than 23 nm
- Findings of previous PMP work
 - Sub 23 nm particles appearing-to-be solid present below PMP

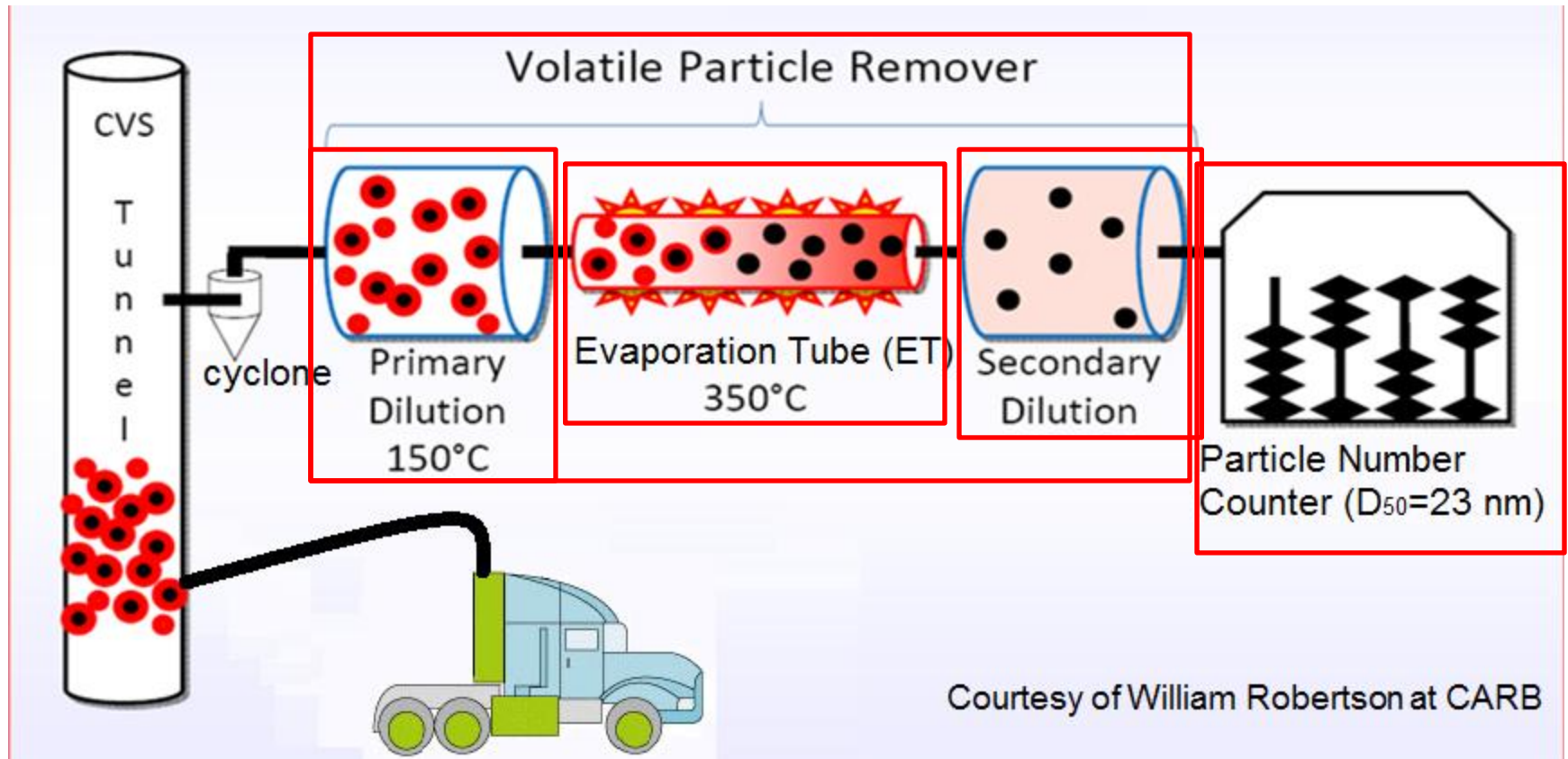


Existence of sub 23 nm particles



What is the nature of these sub 23 nm particles downstream the PMP?

PMP schematic





Objective

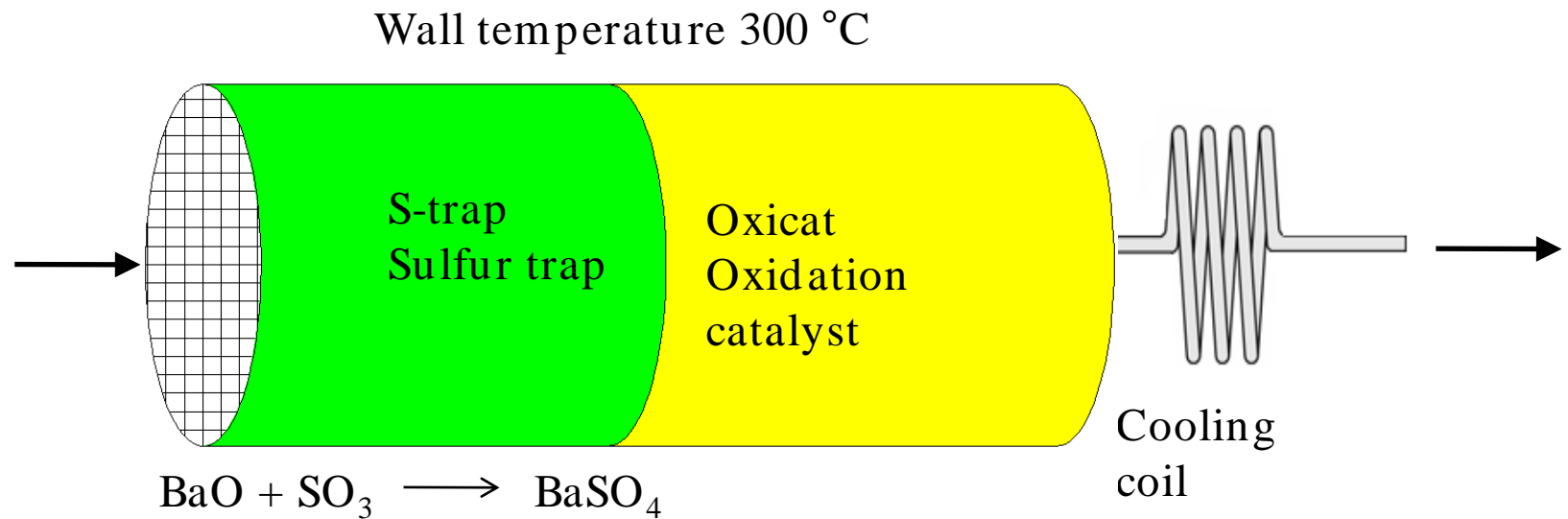
Investigate the nature of the sub 23 nm particles downstream the PMP

Method

Compare the PMP system with another volatile particle remover – Catalytic Stripper (CS)



Catalytic Stripper (CS) schematic





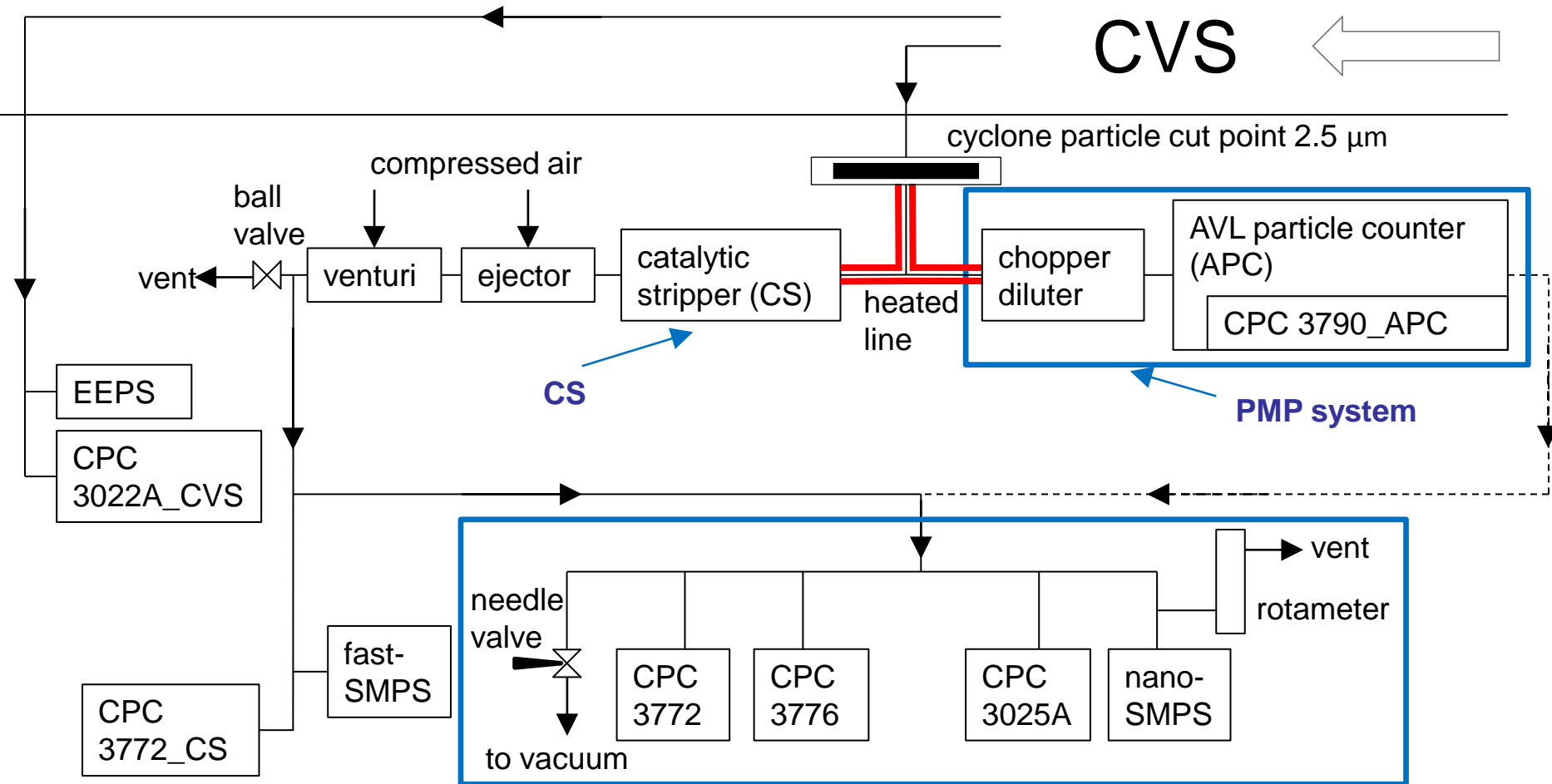


Test conditions

Base	CE-CERT HD Chassis dynamometer
Vehicle	Freightliner class 8
Engine	Caterpillar C-15 (14.6L)
Fuel	ULSD
Lubricating oil	SAE 15W-40
DPF	JM CRT
Vehicle weight	65,000 lb
Truck mileage	41442 miles
Cycles	(a) 56 mph cruise at 74% engine load; (b) 56 mph cruise at 26% engine load.



Experimental setup



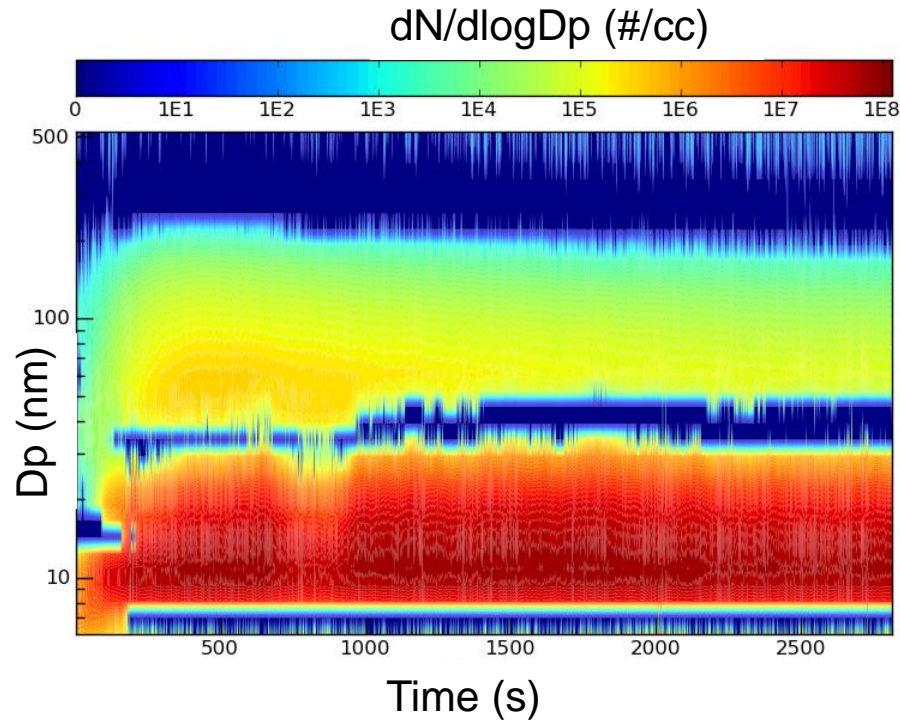
Alternate between the APC and CS



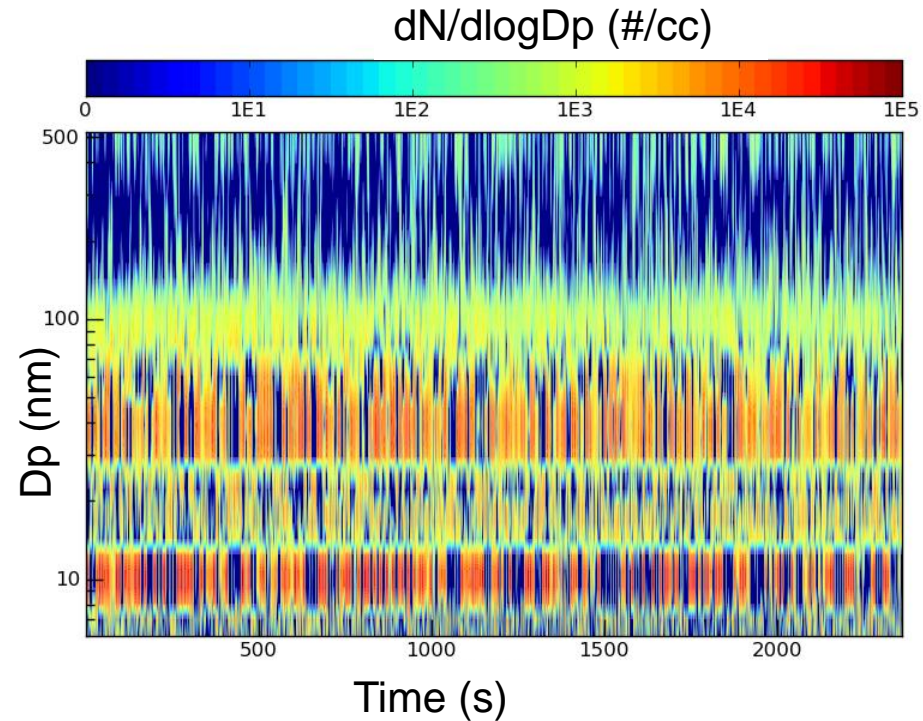
Results



CVS particle size distribution



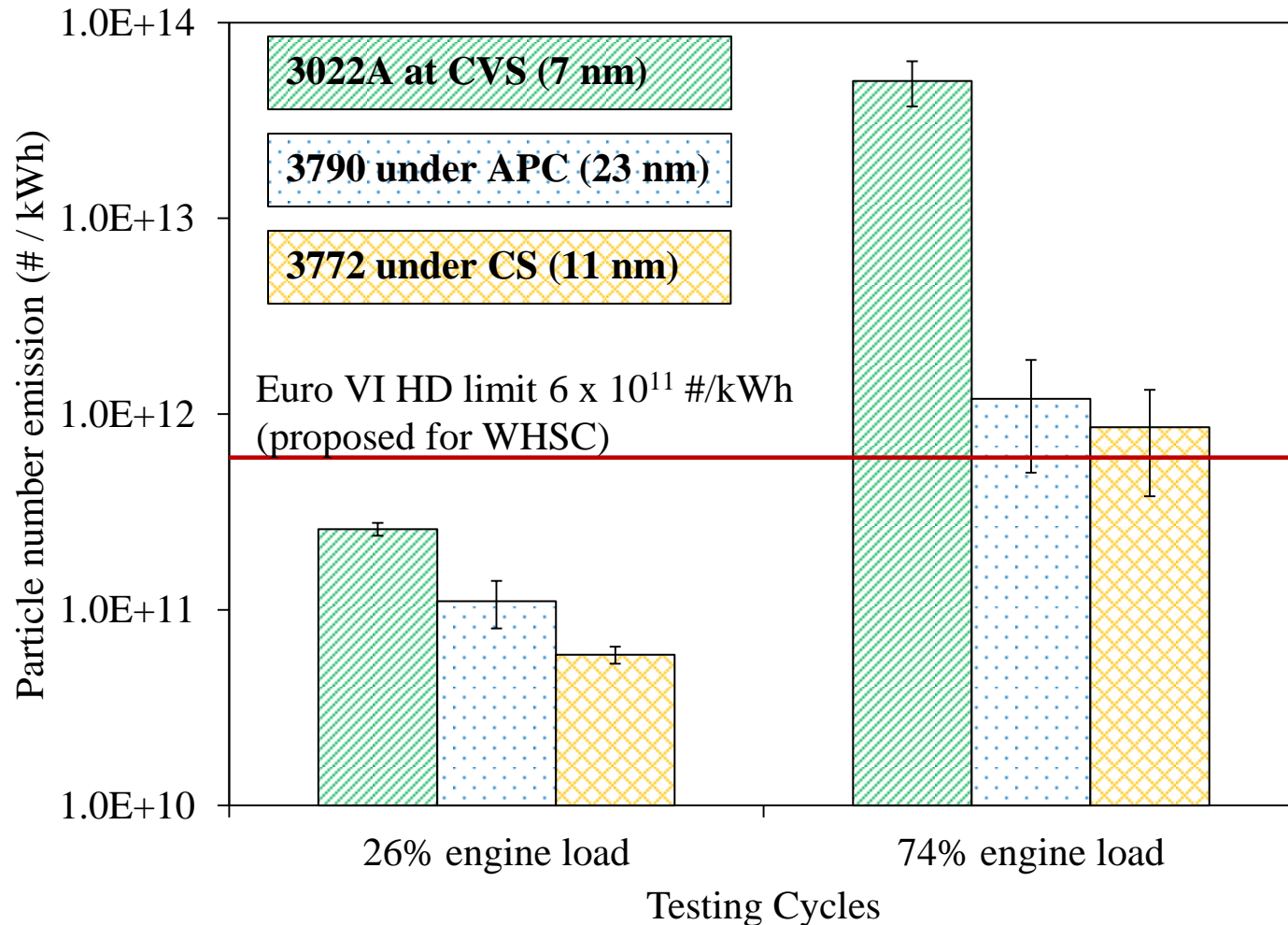
74% engine load



26% engine load

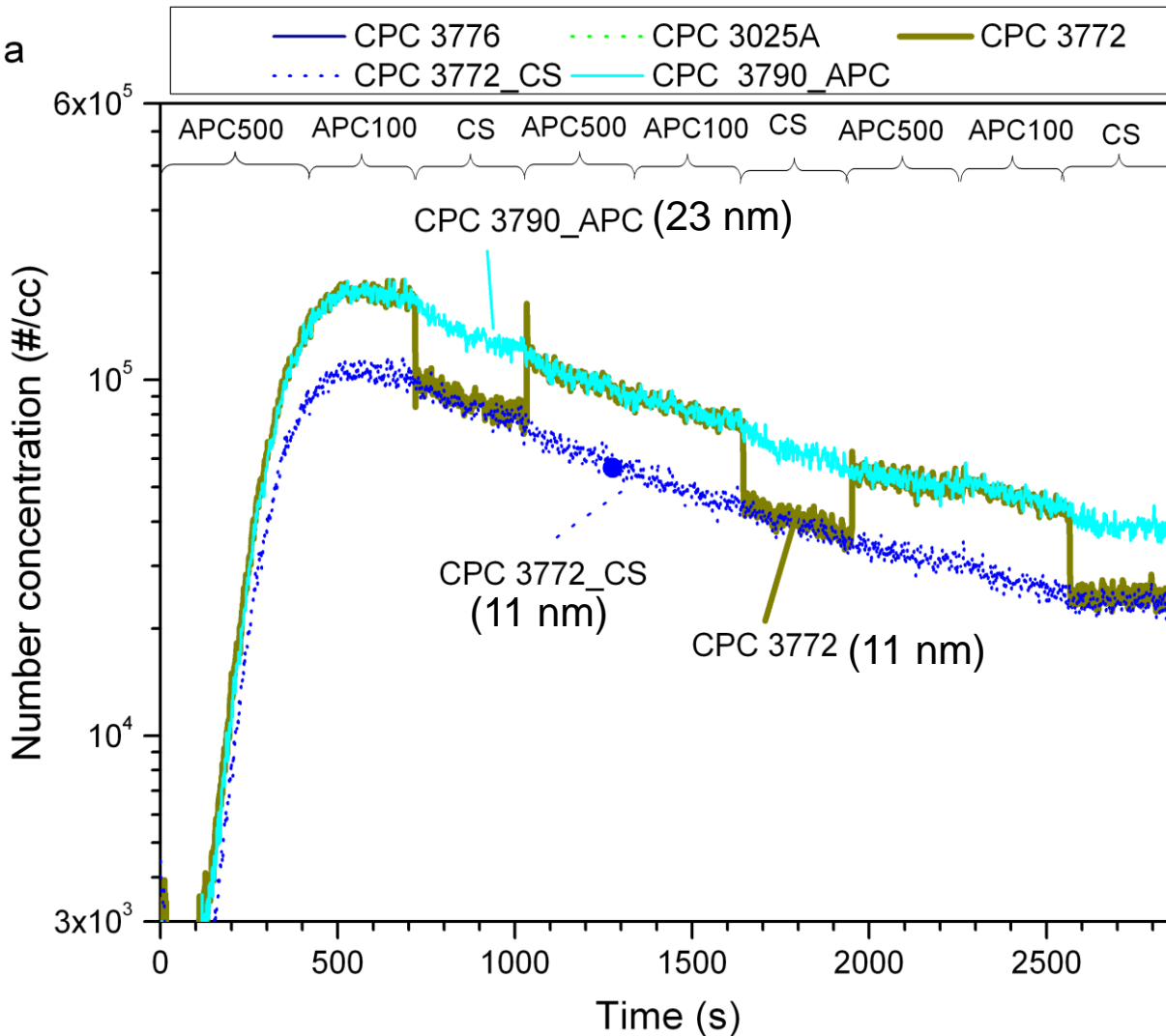


Integrated particle number emissions





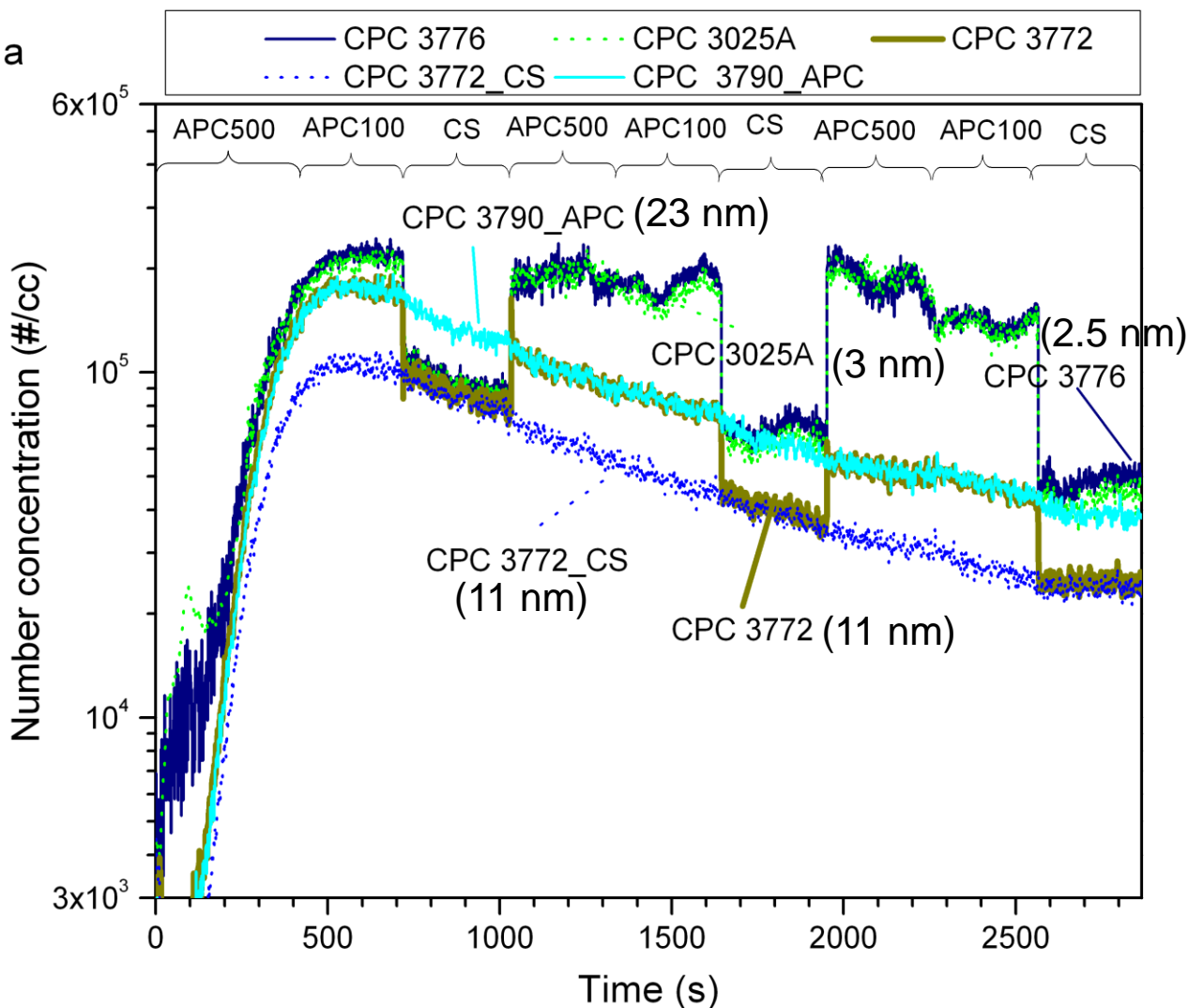
CPC concentrations-74% load



APC showed higher concentration than the CS



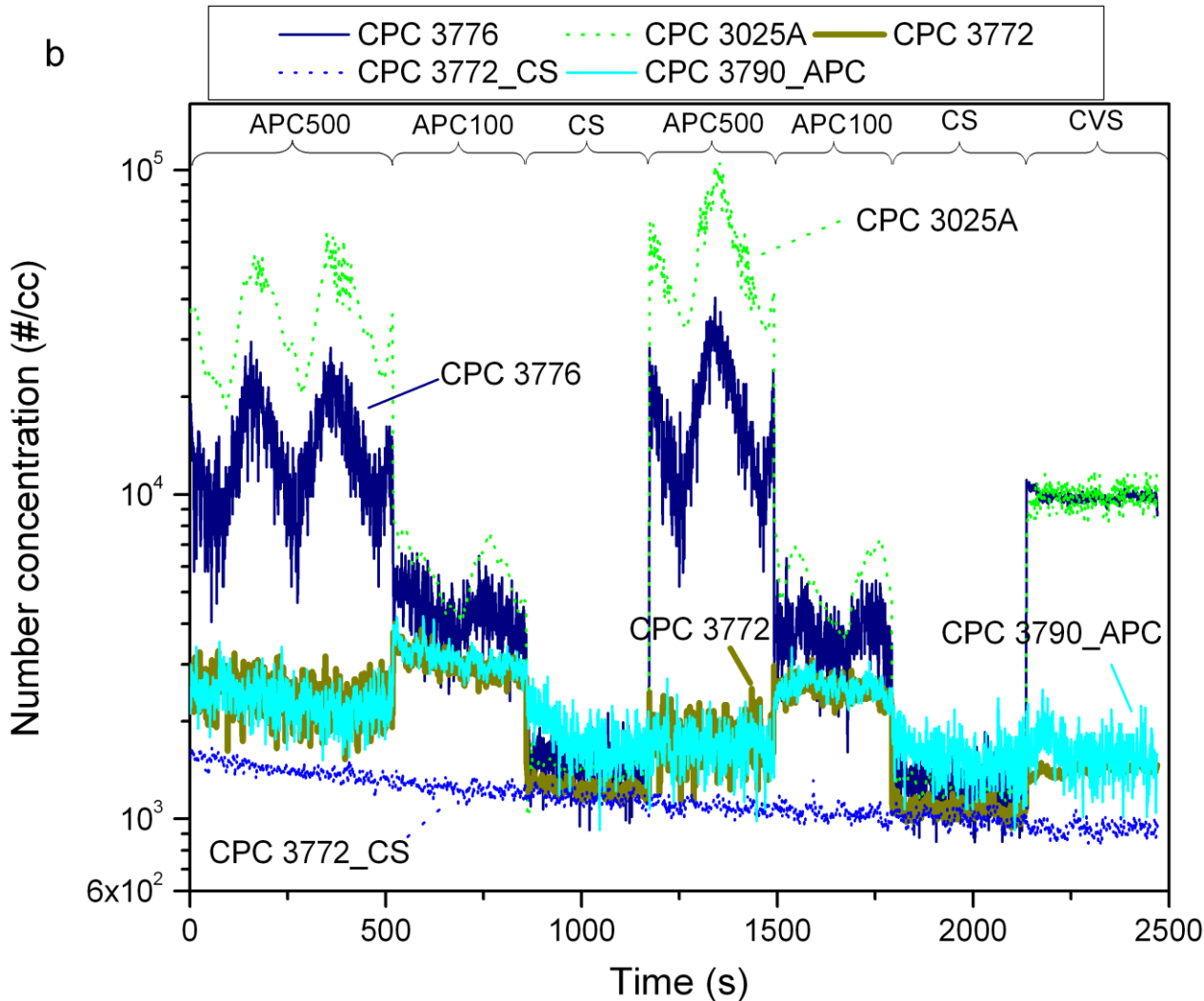
CPC concentrations-74% load



CPCs with smaller cut off diameters showed higher concentration than CPCs with higher cut off diameters



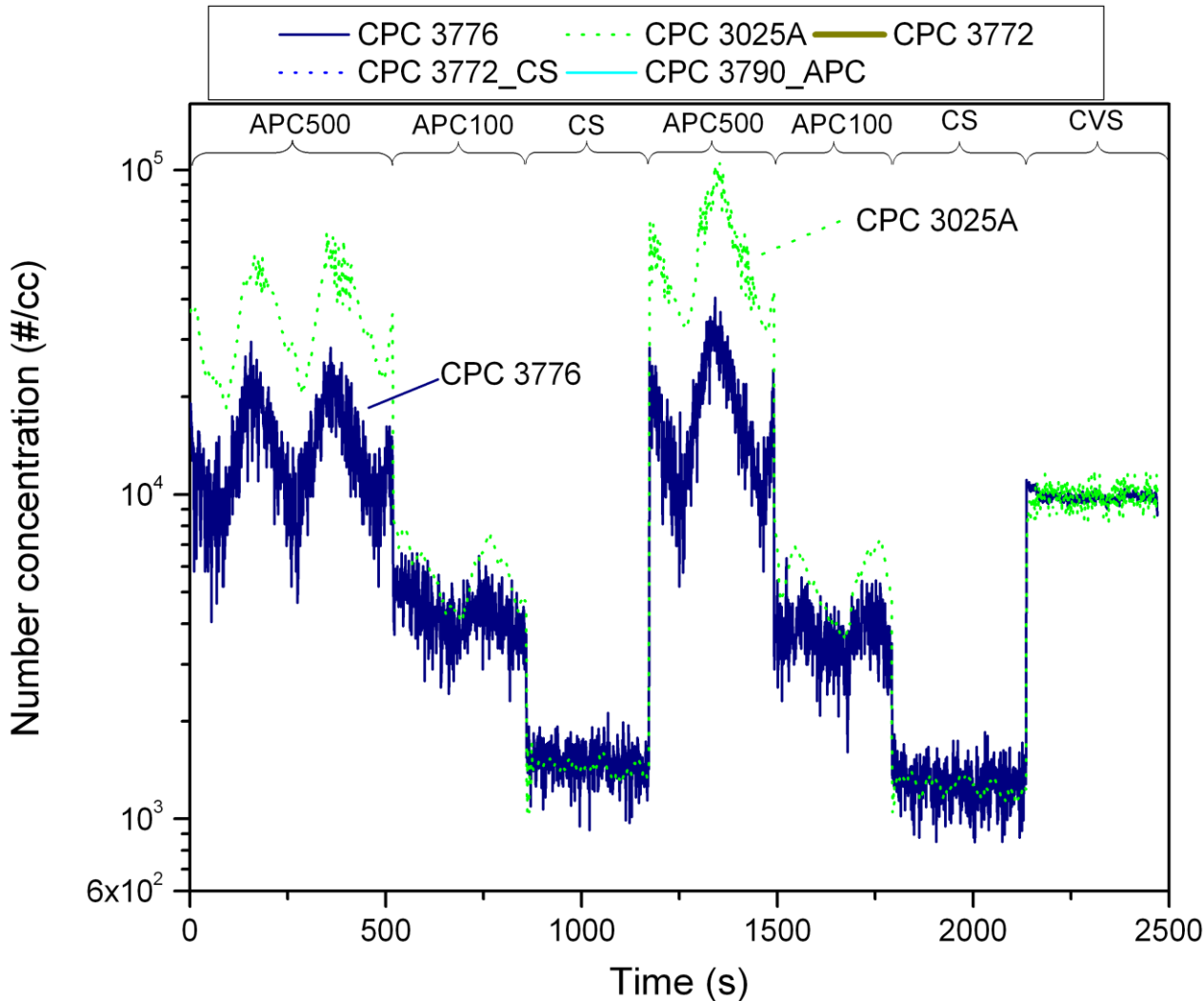
CPC concentrations-26% load



Similar trend
observed at 26%
load



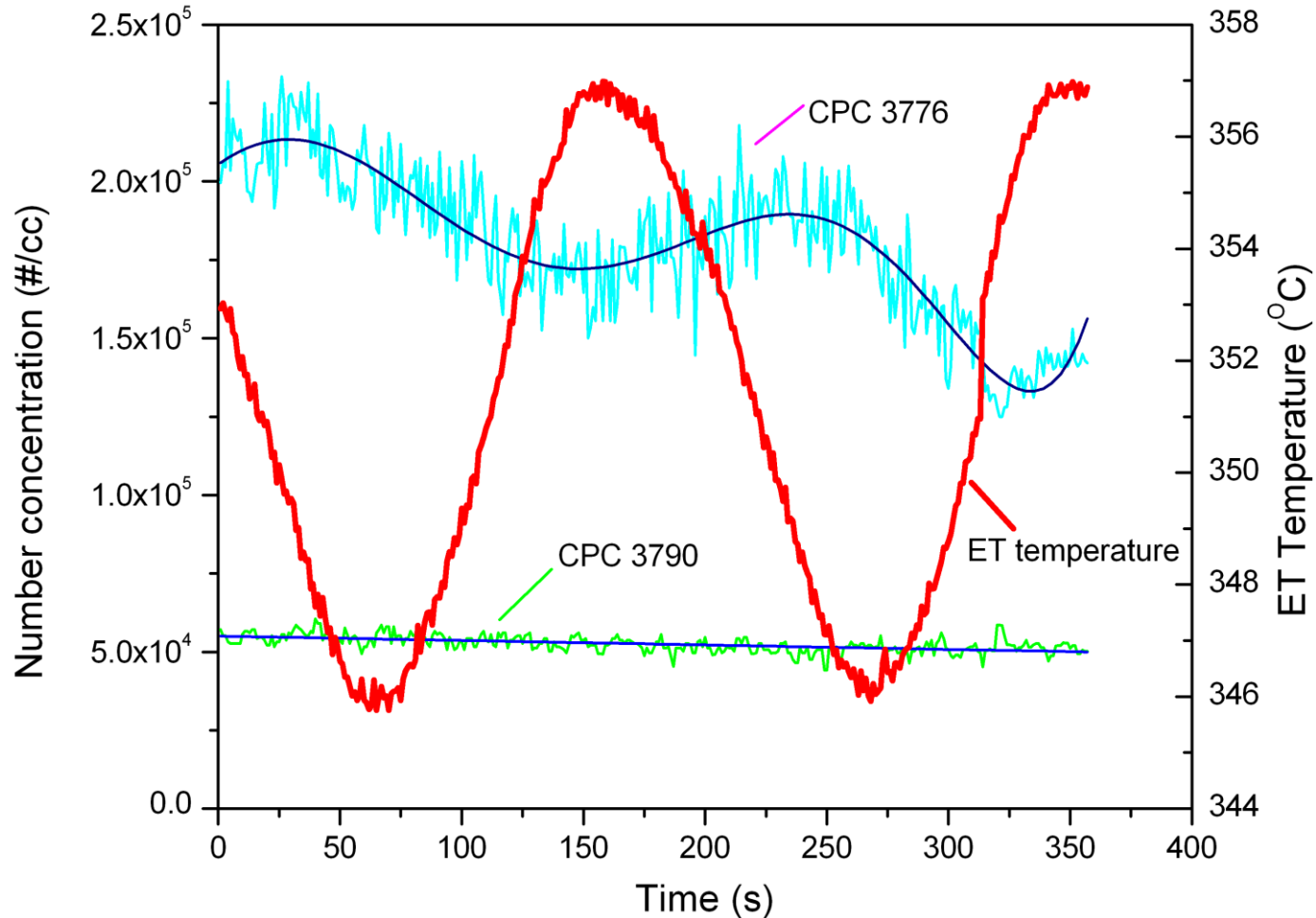
CPC concentrations-26% load

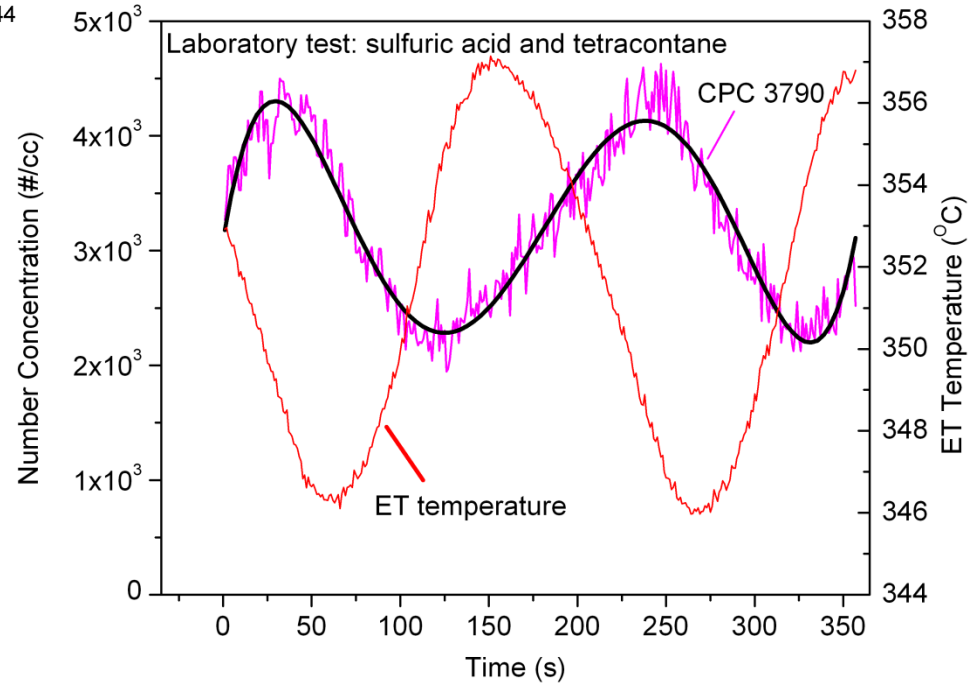
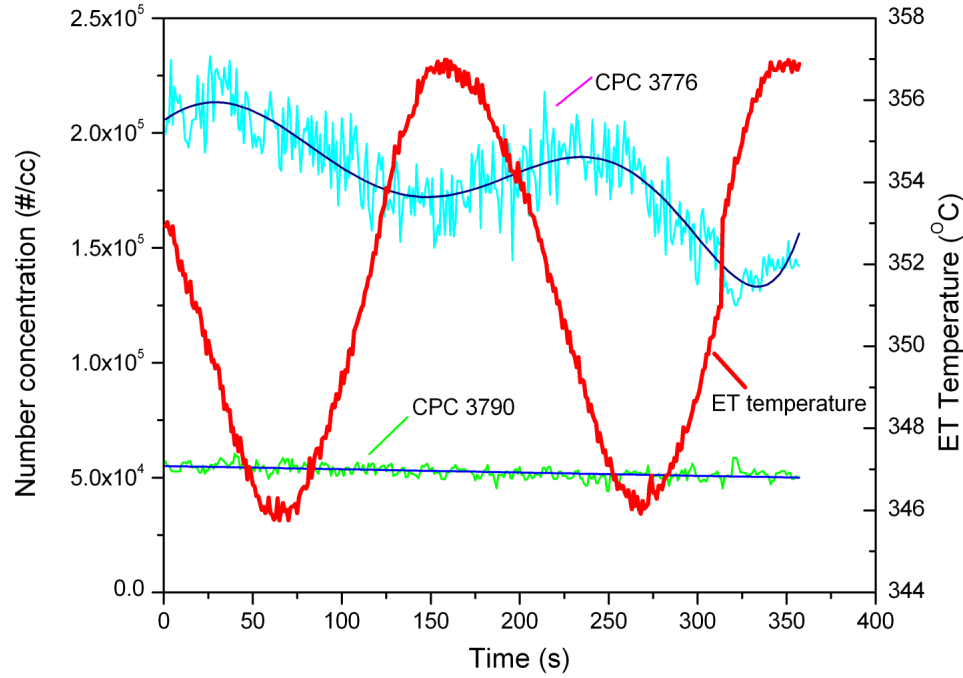


Difference between
CPC 3025A and
3776 indicates:
Particles are
formed due to re-
nucleation of semi-
volatiles
downstream the
PMP



APC ET temperature oscillation







Conclusion

- Particle number emissions for both the PMP and CS were higher than the Euro VI HD limit at the 74% engine load and lower at the 26% engine load.
- Particle number concentrations between 3 and 10 nm downstream the APC were ~ 2 and 7 times higher than the number concentrations of particles above 10 nm at the 74 and 26% engine load, respectively
- Most of the sub 10 nm particles downstream the PMP were formed in the ET of the PMP, because:
 - CPC 3025A had higher concentration than CPC 3776;
 - Particle concentration of those sub 10 nm particles oscillated in relation with the oscillation of the PMP ET temperature.
- The CS showed much less of a tendency to form particles downstream than the APC.



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